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(12) # EUROPEAN PATENT SPECIFICATION

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(54) **A method and apparatus for continuously updating a display of the coordinates of a light pen.**

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Description

This invention relates to graphic data display systems and particularly to such systems in which the position of a locator such as a light pen is displayed.

Users of graphic data display systems use locators such as light pens for cathode ray tube display or stylii for tablets for drawing on the display area. Engineering drawings generated in this manner are required to be accurate within specified tolerances as the resultant drawing can be used directly to control a manufacturing operation under a so-called CAD/CAM system. One such system is the IBM 7361 Fastdraft System (IBM is a registered Trade Mark). The IBM 7361 Fastdraft system includes an IBM 3251 display having a keyboard and a light pen, these comprise a draughting workstation. The display screen displays menus and images within a viewing area. When it is needed, a tracking cross for tracking light pen movement is displayed.

In the IBM 3250 Display System because of the time required for calculations, a digital read-out of the distance and direction traversed by a light pen on the refreshed display is not available until the movement of the light pen is complete. The calculation of the distance and angle traversed by the light pen is performed by the host computer after an interrupt to perform the calculation. This interrupt occurs when the light pen reaches its final point. Such a process is too slow to permit the parameters of the light pen position to be continuously displayed during the light pen movement.

The article 'An Improved Light Pen Tracking Algorithm Based on a Recursive Digital Filter' by Murray Kesselman — Proceedings of the S.I.D. Vol. 14/2 Second Quarter 1973 p. 52 et seq describes an algorithm for light pen tracking that can be used in a time sharing environment. The algorithm is only used for tracking and not for providing a display of a light pen position.

A different scheme to identify the position of a light pen is proposed in the article 'Direct-View Storage Tube Light Pen Attachment' by W. F. Beausoleil and R. A. Linton, IBM Technical Disclosure Bulletin Vol. 21, No. 6, November 1978, p. 2450. The direct view storage tube has circuitry which is used to cause the display screen to be scanned by a series of horizontal lines until a pen hit occurs. The co-ordinates of the pen are then transmitted to a host computer. No refresh buffer is required in the terminal to provide the scanning function which is performed in the write through mode.

US—A—Patent 3,505,561 describes pen-tracing apparatus for use with a computer driven display. A pattern of beam spots on the cathode ray tube centred about a previously determined centre of the pen is within the field of view of the pen. The amplitude of the pen response to each of the spots is compared to determine in which direction the centre of the spots must be moved in order to coincide with the pen centre.

In order to display the pen position using the Beausoleil-Linton scheme the host computer has to calculate the co-ordinates and transmit the result to the display terminal. As with the IBM 3250 Display System this does not permit a continuously updated display during the movement of the pen.

An object of the present invention is to provide a display of a locator position that changes continuously during the movement of the locator across a display area.

The present invention provides a method and apparatus whereby the light pen position parameters can be determined directly by the local display processor, that is a microprocessor dedicated to controlling the display, so that the light pen position display can be updated each refresh cycle without interrupting and delaying the host computer.

According to the invention there is provided a method of providing a continuously updated display, on a display device having a repeating refresh cycle of operations, including the steps of obtaining control of a display processor at the end of each refresh cycle, indicating the current position of a locator device in orthogonal displacements from a fixed reference point, during the movement of the locator device across a display area and returning control to the display processor to start the next refresh cycle, characterised by

a) calculating the distance and direction of the locator from the fixed reference point in polar coordinates and

b) converting the resultant distance and direction values into character form and inserting the characters into a graphic order buffer from which the values will be displayed on the next refresh cycle.

According to a second aspect of the invention there is provided data display apparatus including a display device having a repeating refresh cycle of operations and means to indicate the current position of a locator device in orthogonal displacements from a fixed reference point, whereby the display device displays the current position of the locator device as it moves across a display area, characterised in that the apparatus includes, first means operable at the end of each refresh cycle to calculate the distance and direction of the locator from the fixed reference point and provide the resultant values in polar coordinates, and second means to convert the output of the first means into a character form and to insert the resultant characters into a graphic order buffer from which the values will be displayed on the next refresh cycle.

In order that the invention may be fully understood a preferred embodiment will now be described with reference to the accompanying drawings in which:

FIG. 1 is a block schematic diagram illustrating the components of a directed beam display system.

FIG. 2 is a block schematic diagram illustrating the component parts of a display terminal controller.

The preferred embodiment of the invention is in a directed beam display system such as shown FIG. 1,

however the invention finds application in raster beam display devices and in tracking stylii used on graphic tablets having an associated display.

In general terms the invention makes use of the microprocessor in the display controller that is dedicated to controlling the display so that the read-out can be updated each refresh cycle without interrupting and delaying the host computer. The method involves executing a single iteration of a Newton-Raphson approximation every refresh cycle of the display. In the first step the absolute screen co-ordinates are updated by the light pen tracking system and converted to application co-ordinates based on parameters written by the host computer into the display buffer work space. The orthogonal displacements, dx and dy, from a fixed reference point (also written in the work space) is determined by subtraction. The maximum of dx and dy is then determined.

The distance and direction values from a reference point are then determined, converted into character form and inserted into the display buffer orders. The results are then continuously updated on the screen.

Referring now to Figure 1 in which a block schematic of a display system is shown. A display controller 1 is connected to a host data processing system 2 through a cable link 3. The controller 2 has connections to a display head 4, a keyboard 5, and a light pen 6. The system shown is typical of any IBM 3250 Display System and the controller 2 may also have a graphic tablet and stylus attached.

In such a system the user controls the light pen 6 to indicate portions of the display head screen or to draw lines on the screen. When the system is used for a computer aided design (CAD) then the accuracy with which drawings are generated is important. It is in helping the user to achieve accurate drawings that the invention finds its use.

The display on the display head 4 is controlled by the controller 1. Figure 2 is a block schematic of the portions of the controller which are used for implementing the preferred embodiment of the invention.

Referring now to Figure 2 there is shown a graphic control processor 10 which has output connections to the display head and the light pen on lines 11 and 12 and a display processor 13 which has an input connection from the keyboard on line 14. Both the graphic and display processors are connected to a common bus 15. A store 16 comprising a 32K Random Access Memory (RAM) and a 32K of RAM and Read Only Memory (ROM) is also connected to the common bus 15. An input-output controller 17 which has the line 18 connection to the host computer is also connected to the common bus 15.

The parameter for controlling the current display frame are contained in a refresh buffer which is part of the 32K RAM of store 16. During normal operation the display processor reads out the refresh buffer forty six times a second and the graphic controller thus regenerates the display screen forty six times a second. The control for the display processor is contained in the 32K RAM/ROM of store 16 and includes the control for implementing the present invention. This control may be implemented in a hard wired logic circuit or as microcode stored in that 32K.

The RAM portion of store 16 includes a graphic order buffer into which a display of characters indicating the light pen position with regard to a reference point are placed.

During each refresh cycle the position of the light pen is noted by the graphic control processor and entered into parameter register in the RAM store.

In a directed beam display the refresh cycle is dependent upon the content of the screen. Thus a picture with only a few lines will have a much shorter refresh time than a more complex picture. A maximum refresh rate of 46 times a second, means that the nominal time for each cycle is 21 milliseconds. When the user is drawing lines the picture will be relatively simple and the processor will not need the 21 milliseconds to perform the refresh. It is the recognition of this factor that allows the implementation of the present invention without requiring additional processing capacity.

In operation of a display system the host computer will provide a menu display from which the user selects the operation that is to be performed. When the user requires to draw a line he points the light pen at the appropriate portion of the displayed menu. The host computer detects the light pen selection. If a 'draw' is required the host computer displays the appropriate pen follower symbol at a predetermined position on the screen. The parameters of the position are loaded into the controllers display buffer and these are used as the reference point for determining the movement of the light pen. The method of the preferred embodiment will now be described. At the end of each refresh cycle the control of the processor is obtained by the control code of the light pen tracking operation, the following steps are taken before the next refresh cycle starts.

Step 1

The screen coordinates of the light pen which have been updated by a light pen tracking routine during the previous refresh cycle, are converted, based on parameters written by the host computer into the display buffer, into orthogonal displacements (dx, dy) in application units from a fixed reference point.

Step 2

A comparison is made of dx and dy to determine the range in which the required angle falls, such that the tangent (t) of an angle less than 45° is calculated.

Step 3

The following table gives the quadrant range of the angle to be calculated (+x axis = 0°). The maximum length (L) of dx and dy is calculated, as shown in the following table.

dy+dx Result	dy−dx Result	Angle	L	t
+	+	45-135	dy	−dx/dy
−	+	135-225	−dx	dy/dx
−	−	225-315	−dy	dx/−dy
+	−	315- 45	dx	dy/dx

The special cases of dx=dy=0 or t=1 are recognised at this stage, and in these cases the following Step 4 is not needed.

In the general case, finding the polar coordinates is now reduced to finding the angle A and distance D in a right angle triangle in which D is the hypotenuse = $L\sqrt{1 + t^2}$, L is the adjacent side to angle A and L.t where $0 < t < 1$ is the opposite side.

Step 4

The control system then performs a single step of several Newton-Raphson approximations as follows:

a) Expressing D as L(1 + s) it is required to solve:

$$(1 + s)^2 = 1 + t^2$$

The appropriate approximation is

$$s' = \frac{s^2 - t^2}{2(1 + s)}$$

b) Expressing u = tan (A/2) the appropriate approximation is:

$$u' = \frac{tu^2 + t}{2(tu + 1)}$$

c) Expressing v = tan (A/4) the appropriate approximation is:

$$v' = \frac{uv^2 + u}{2(uv + 1)}$$

d) Expressing w = tan (A/8) the appropriate approximation is:

$$w' = \frac{vw^2 + v}{2(vw + 1)}$$

The result of executing this step on successive display cycles is that s, u, v, w progressively approach the correct values describing the position of the light pen. If the light pen is moving they will effectively follow it. The range of values for w permits A/8 to be found with reasonable accuracy using only two terms of the arc tangent expansion. This convergence depends upon the parameters having been initially within certain ranges as follows:

$$s > -1$$
$$-1 < u < +1$$
$$-1 < v < +1$$
$$-1 < w < +1$$

Step 5

The distance and direction of the light pen from the fixed reference point are calculated using the current approximation of s and w. These are then converted into character form and inserted in the graphic order buffer so that the values will be displayed on the next refresh cycle.

Step 6

A check is made to determine whether a new position for the light pen is detected for several cycles, e.g. 4. If there is no new position then steps 4 and 5 are suppressed.

Step 7

Control is returned to the display processor to start the next refresh cycle and to display on the screen an indication of the light pen position in polar coordinates.

Claims

1. A method of providing a continuously updated display, on a display device (4) having a repeating refresh cycle of operations, including the steps of obtaining control of a display processor (13) at the end of each refresh cycle, indicating the current position of a locator device (6) in orthogonal displacements from a fixed reference point, during the movement of the locator device across a display area and returning control to the display processor (13) to start the next refresh cycle, characterised by

a) calculating the distance (D) and direction (angle A) of the locator from the fixed reference point in polar coordinates and

b) converting the resultant distance and direction values into character form and inserting the characters into a graphic order buffer (16) from which the values will be displayed on the next refresh cycle.

2. A method as claimed in claim 1 in which step (a) includes the calculation of the angle and distance of travel of the locator (6) by a series of approximations.

3. Data display apparatus including a display device (4) having a repeating refresh cycle of operations and means to indicate (1) the current position of a locator device (6) in orthogonal displacements from a fixed reference point, whereby the display device (4) displays the current position of the locator device (6) as it moves across a display area, characterised in that the apparatus includes, first means operable at the end of each refresh cycle to calculate the distance and direction of the locator (6) from the fixed reference point and provide the resultant values in polar coordinates (distance D, angle A) and second means to convert the output of the first means into a character form and to insert the resultant characters into a graphic order buffer (16) from which the values will be displayed on the next refresh cycle.

4. Data display apparatus as claimed in claim 3 in which the first means is operable to determine the angle of travel of the light pen and to determine the polar coordinates of the position of the light pen with regard to a reference point by a series of approximation calculations.

5. Data display apparatus as claimed in claim 3 or claim 4 in which the display area (4) is a cathode ray tube and the locator (6) is a light pen.

6. Data display apparatus as claimed in any one of claims 3, 4 or 5 operable to perform the method claimed in claim 1 or claim 2.

Patentansprüche

1. Verfahren für eine kontinuierlich aktualisierte Anzeige auf einem Anzeigegerät (4) mit einem sich wiederholenden Arbeitszyklus, wobei die Steuerung durch einen Bildprozessor (13) am Ende eines jeden Wiederholzyklus' erhalten, die aktuelle Position eines Positionsanzeigers (6) in orthogonalen Verschiebungen von einem festen Bezugspunkt während der Bewegung des Positionsanzeigers durch einen Anzeigebereich angezeigt und die Steuerung an den Bildprozessor (13) für den Start des nächsten Wiederholzyklus' zurückgegeben wird, gekennzeichnet durch

a) die Berechnung der Entfernung (D) und der Richtung (Winkel A) des Positionsanzeigers vom festen Bezugspunkt in Polarkoordinaten und durch

b) Umwandlung der daraus resultierenden Entfernungs- und Richtungs- werte in Zeichenform und Einfügen der Zeichen in einen graphischen Auftragspufferspeicher (16), von dem aus die Werte während des nächsten Wiederholzyklus' angezeigt werden.

2. Verfahren nach Anspruch 1, dadurch gekennzeichnet, daß in Schritt a) Bewegungswinkel und -richtung des Positionsanzeigers (6) mittels einer Folge von Näherungswerten berechnet werden.

3. Datenanzeigevorrichtung, mit einem Anzeigegerät (4) mit einem sich wiederholenden Arbeitszyklus und mit einer Einrichtung (1) für die Anzeige der aktuellen Position eines Positionsanzeigers (6) in orthogonalen Verschiebungen von einem festen Bezugspunkt, wobei das Anzeigegerät (4) die aktuelle Position des Positionsanzeigers (6) während dessen Bewegung durch einen Anzeigebereich anzeigt, gekennzeichnet durch eine erste Einrichtung, welch am Ende jedes Wiederholzyklus' Entfernung und Richtung des Positionsanzeigers (6) von einem festen Bezugspunkt berechnet und die daraus resultierenden Werte in Polarkoordinaten (Entfernung D, Winkel A) liefert und durch eine zweite Einrichtung, welche die Ausgabe der ersten Einrichtung in Zeichenform umwandelt und die daraus resultierenden Zeichen in einen graphischen Auftragspufferspeicher (16) einfügt, von dem aus die Werte während des nächsten Wiederholzyklus' angezeigt werden.

4. Datenanzeigevorrichtung nach Anspruch 3, dadurch gekennzeichnet, daß die erste Einrichtung den Bewegungswinkel des Lichtgriffels und die Polarkoordinaten der Position des Lichtgriffels im Hinblick auf einen Bezugspunkt durch eine Folge von Näherungsberechnungen bestimmt.

5. Datenanzeigevorrichtung nach Anspruch 3 oder 4, dadurch gekennzeichnet, daß das Anzeigegerät (4) eine Kathodenstrahlröhre und der Positionsanzeiger (6) ein Lichtgriffel ist.

6. Datenanzeigevorrichtung nach einem der Ansprüche 3, 4 oder 5, dadurch gekennzeichnet, daß sie das Verfahren nach den Ansprüchen 1 oder 2 durchführt.

Revendications

1. Procédé pour obtenir un affichage continuellement mis à jour, sur un visuel (4) disposant d'un cycle de régénération d'opérations à répétition, comprenant les étapes consistant à obtenir la commande d'un processeur de visualisation (13) à la fin de chaque cycle de régénération, à indiquer la position actuelle d'un dispositif localisateur (6) en déplacements orthogonaux par rapport à un point fixe de référence, pendant le mouvement du localisateur à travers une surface de visualisation et à renvoyer la commande au processeur de visualisation (13) pour lancer le prochain cycle de régénération, caractérisé par le fait

a) qu'on calcule la distance (D) et la direction (angle A) du localisateur par rapport au point fixe de référence, en coordonnées polaires, et

b) qu'on convertit les valeurs résultantes de distance et de direction sous forme de caractères et qu'on introduit les caractères dans un registre d'instructions graphiques (16) à partir duquel les valeurs seront affichées au cours du prochain cycle de régénération.

2. Procédé selon la revendication 1, caractérisé par le fait quel'étape (a) inclut le calcul de l'angle et de la distance de déplacement du localisateur (6) par une série d'approximations.

3. Appareil de visualisation de données comprenant un visuel (4) ayant un cycle de régénération d'opérations à répétition et un moyen (1) pour indiquer la position actuelle d'un localisateur (6) en déplacements orthogonaux par rapport à un point fixe de référence, grâce à quoi le visuel (4) affiche la position actuelle du localisateur (6) tandis qu'il se meut à travers une surface d'affichage, caractérisé par le fait que l'appareil comprend un premier moyen pouvant être mis en oeuvre à la fin de chaque cycle de régénération pour calculer la distance et la direction du localisateur (6) par rapport au point fixe de référence et fournir les valeurs résultantes en coordonnées polaires (distance D, angle A), et un second moyen pour convertir la sortie du premier moyen sous forme de caractères et pour introduire les caractères résultants dans un registre (16) d'instructions graphiques à partir duquel les valeurs seront affichées lors du prochain cycle de régénération.

4. Appareil de visualisation de données selon la revendication 3, caractérisé par le fait que le premier moyen peut être mis en oeuvre pour déterminer l'angle de déplacement du photostyle et pour déterminer les coordonnées polaires de la position du photostyle par rapport à un point de référence, par une série de calculs approchés.

5. Appareil de visualisation de données selon la revendication 3 ou 4, caractérisé par le fait que la surface d'affichage (4) est un tube à rayons cathodiques et que le localisateur (6) est un photostyle.

6. Appareil de visualisation de données selon l'une quelconque des revendications 3, 4 et 5, caractérisé par le fait qu'il peut être mis en oeuvre pour appliquer le procédé de la revendication 1 ou de la revendication 2.

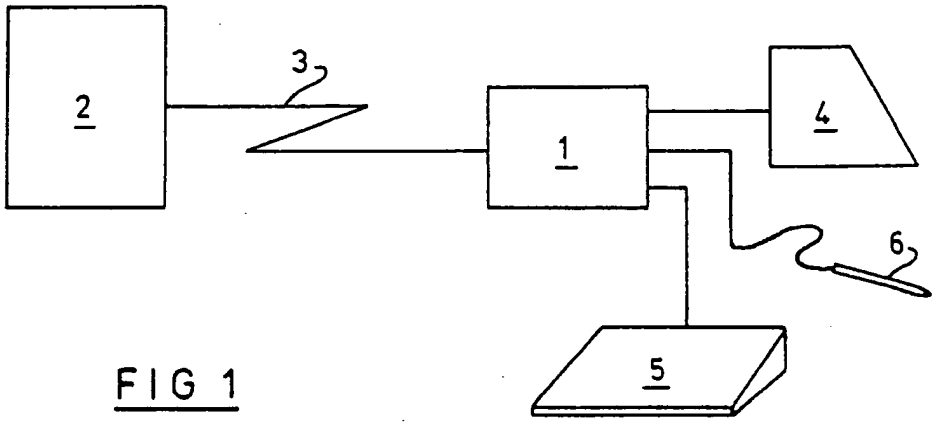

FIG 1

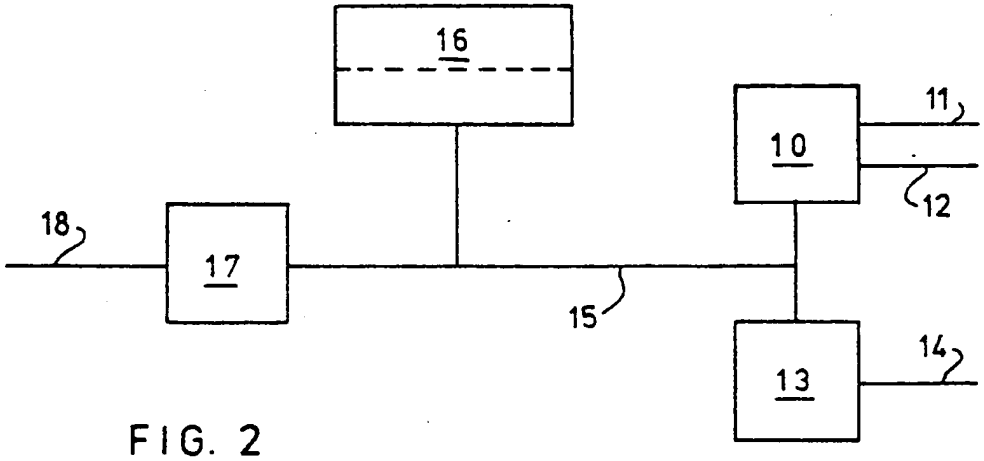

FIG. 2